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A PILOT STUDY OF AIR POLLUTION IN BIRMINGHAM, ALABAMA

Seymour Hochheiser, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

May 1962

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TECHNICAL REPORT
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A PILOT STUDY OF AIR POLLUTION IN BIRMINGHAM ALABAMA

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A Joint Study by the City of Birmingham,
JEFFERSON COUNTY DEPARTMENT OF HEALTH,
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A PILOT STUDY OF AIR POLLUTION IN BIRMINGHAM, ALABAMA

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Details of illustrations in this document may be better studied on microfiche.

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

May, 1962

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A PILOT STUDY OF AIR POLLUTION IN BIRMINGHAM, ALABAMA

SUMMARY

In 1961 the City of Birmingham and Jefferson County, Alabama, in the interest of the control of air pollution, conducted a short-term, two-season air quality study. This study was carried out, with the assistance of the Public Health Service, in two parts of 3 weeks each, June 15 through July 4 and November 29 through December 19. Air samples were collected for measurement of dustfall, suspended particulates, smoke shade, sulfur dioxide, nitrogen oxides, total oxidants, carbon monoxide, and hydrogen sulfide.

Air pollution data obtained during the summer phase of the study can be considered representative. Air pollution levels recorded for the fall do not reflect normal conditions, however, because of a record heavy rainfall and stormy conditions, which favored dispersion and removal of air pollutants.

Pollution levels might have been different at sampling sites other than those selected and certainly would have been higher under weather conditions less favorable to dispersion, i.e., prolonged periods of air stagnation, which did not occur during the study periods.

The concentrations of gaseous pollutants were generally low, but occasionally relatively high concentrations were recorded. Mean values were: sulfur dioxide, 0.01 ppm; nitrogen oxides, 0.04 ppm; oxidants, 0.03 ppm; and carbon monoxide, 1.8 ppm. Maximum levels measured were: sulfur dioxide, 0.18 ppm; nitrogen oxides, 0.14 ppm; oxidants, 0.14 ppm; carbon monoxide, 12.5 ppm. Since an upward trend in motor vehicle use and a growth in other air pollution sources is evident in Birmingham, these gaseous pollutants will play an increasingly greater role in the air pollution problem unless controls are effected.

Particulate pollutants, notably dustfall, smoke, and total suspended particulates, occasionally were found to be very high in spite of good atmospheric dispersion conditions, particularly during the fall; this indicates the need for control of emissions of particulate matter into the atmosphere. Mean values for the fall study were: dustfall, 76 tons/mi^2 per month; smoke concentration, 1.5 cohs/1000 linear feet; and suspended particulates, 113 $\mu g/m^3$. Maximum levels were: dustfall, 121 tons/mi^2 per month; smoke concentration, 6.2 cohs/1000 linear feet; and suspended particulates, 279 $\mu g/m^3$.

Mean values for the summer study were: dustfall, 49.3 tons/mi^2 per month; smoke concentration, 0.6 cohs/1000 linear feet; and suspended particulates, 106 $\mu g/m^3$. Maximum levels were: dustfall 95.6 tons/mi^2 per month; smoke concentration, 3.0 cohs/1000 linear feet; and suspended particulates, 206 $\mu g/m^3$.

Substantially higher levels of particulate and gaseous pollutants were recorded in the fall, indicating that emissions resulting from the combustion of fuels for industrial, commercial, and domestic space heating contribute significantly to over-all air pollution during the heating season.

RECOMMENDATIONS

Based on the results of the pilot air quality study, results of a previous air pollution survey of the Birmingham area, and the increasing importance of conserving our air resources, it is recommended that the Birmingham metropolitan area:

1. Institute an effective air pollution program aimed at minimizing emissions of particulate matter into the atmosphere, as follows:

   a. Establish limits for stack emissions of particulate matter; these may be based upon an estimate of air pollution sources and emissions, a stack sampling program to determine which of certain industrial or domestic and commercial emissions are excessive, and an evaluation of the performance of abatement equipment.

   b. Continue the dustfall sampling network; determine suspended particulate matter levels at strategic locations by means of strip filter paper samplers and high-volume air samplers.

2. Conduct a long-term air pollution monitoring program of modest magnitude to characterize the problem more fully, to assess the need for and the effect of various control activities, and to follow trends in air pollution levels. For this purpose, an air monitoring station should be established near the downtown shopping area. Analyses of gaseous and particulate pollutants should be made.

3. Conduct an informational program to acquaint citizens with the causes, effects, and methods of control of air pollution, and with the control efforts being made in the Birmingham area so that active public support can be maintained.

4. Keep abreast of research and developments in the air pollution field so that the latest technology can be applied.

INTRODUCTION

BACKGROUND

Birmingham, Alabama, one of our Nation's leading industrial centers, is in the heart of the rich iron, coal, and limestone belt of the southern Appalachian Mountain range. Because of the wealth of natural resources in the area, Birmingham has become a leading primary-metals manufacturing city; the City's major manufacturing facilities also produce fabricated metal products; transportation equipment; machinery; stone, clay, and glass products; and lumber and wood products.

The Greater Birmingham area is located in Jones Valley, which is approximately 600 feet above sea level, 8 miles long, and 2 to 4 miles wide, between a ridge of hills and the Red Mountain Ridge. The mountain-valley type of topography results in wind channeling and increases the incidence of atmospheric temperature inversions that tend to confine pollutant emissions resulting from the combustion of fuels and from industrial and other activities.

A major climatic effect of the mountain-valley topography of Birmingham occurs during the fall and winter months when ideal radiation and pronounced cold air drainage produces inversions and rather low minimum temperatures. Associated with this effect is a marked reduction in visibility in the early morning and late afternoon caused by accumulation of smoke and, to a lesser extent, fog.

In 1945, governmental officials of Birmingham recognized the existence of a local air pollution problem and enacted an ordinance prohibiting emission of dense smoke (greater than Ringleman 3). A smoke inspector was appointed to enforce the ordinance.

In July and August of 1956, during and after a steel strike, a special air sampling study was conducted to determine the effect of the steel shutdown on suspended particulate pollution levels. Sampling was conducted both during and after the strike. Results showed that the concentrations of suspended particulate material increased significantly when the industry resumed activity.[1]

In 1957, the Director of the Jefferson County Department of Health and the Birmingham Commissioner of Public Improvement saw the need for an improved and expanded air pollution control program. Technical assistance was requested from the Public

Health Service to aid in a joint survey, which would more precisely evaluate existing and potential air pollution problems.[2] Among the salient recommendations were:

1. Efforts to control air pollution in the Birmingham area should be considerably expanded.

2. The 1945 Smoke Control Ordinance for Birmingham should be supplanted by up-to-date air pollution control legislation for the entire county; enabling legislation by the State should be recommended and supported as required.

3. A County-wide program of study, surveillance, prevention, and control of air pollution should be developed.

PURPOSE AND SCOPE

In 1961, the Director of the Jefferson County Department of Health and the Birmingham Commissioner of Public Improvements in cooperation with the Public Health Service decided to conduct an air quality study. The objectives of this study were to:

1. Obtain information on community air quality.

2. Determine seasonal variations in pollution levels.

3. Appraise the air pollution problem and recommend methods for its control.

4. Train local personnel in the techniques and the use of air pollution monitoring equipment.

5. Encourage local participation in air pollution control activities.

CONDUCT OF STUDY

A chemist from the Technical Assistance Branch, Division of Air Pollution, Public Health Service, and an engineer from the Jefferson County Department of Health collected and analyzed the air samples. Employees of the Jefferson County Department of Health and the Division of Smoke and Boiler Inspection assisted in the selection and maintenance of measuring sites and equipment.

The study was in two parts, each covering a 3-week period. In the first phase conducted June 15 through July 4, 1961, summertime air quality levels were measured; in the second phase, November 29 through December 19, 1961, air quality levels during the space heating season were measured.

Air samples were collected at a central station with equipment located in and on the roof of the Jefferson County Department of Health Building and were analyzed for gaseous pollutant content. Total particulates were measured in samples taken from the roof of the adjacent Alabama Medical Center Building. For a brief period during the fall study, a second sampling station was operated in North Birmingham; samples from this site were measured for sulfur dioxide and suspended particulates. Dustfall was collected at 12 sites representing rural, residential, commercial, and industrial areas.

Air samples were collected by manual sampling techniques for one-half-hour periods at 2-hour intervals, from 8 am to 4:30 pm. During the summer phase, air samples for oxidant analysis were collected for 15 minutes every hour. Sampling was also performed on a 24-hour-per-day basis on three consecutive days during the summer and two during the fall to determine nocturnal fluctuation of air pollution levels.

Gaseous pollutants measured were: sulfur dioxide, nitric oxide, nitrogen dioxide, carbon monoxide, and oxidants. An automatic sequential gas sampler was used at the North Birmingham sampling site to obtain comparative measurements of sulfur dioxide. Air samples for determination of hydrogen sulfide were also collected during the summer at Tarrant City Hall, Ensley Health Center, East Birmingham Fire Station, and at the Jefferson County Department of Health. Automatic strip filter paper samplers were used, with lead acetate impregnated filter paper.

Particulate matter was determined continuously throughout the study periods by three different methods:

1. Consecutive 24-hour cumulative samples were obtained with a high-volume air sampler with glass fiber filters.

2. Twelve 2-hour samples were collected each day and analyzed with ABH strip filter paper sampler and photoelectric densitometer.

3. Dustfall was collected in plastic buckets containing distilled water, a fungicide and anti-freeze (during the fall months). The dustfall gauges were mounted on support rods and bases and on flat roof-tops, two to four stories above ground level. The dustfall containers were exposed for a period of 22 to 24 days. Both insoluble and soluble solids were included in the dustfall measurements.

Visibility observations in each of three directions were recorded three times daily. Photographs were taken to document visibility restrictions. Observations were made from the roof

of the Jefferson County Department of Health Building, 1912 Eighth Avenue South. Meteorological data were obtained from the U.S. Weather Bureau Station at the airport.

DISCUSSION OF RESULTS

PARTICULATE POLLUTANTS

Three particulate pollution levels were measured, namely, smoke shade, suspended particulate loading, and dustfall. In general, particulate pollution was high, indicating the need for control of emissions.

Smoke Shade

Smoke shade is an index of the amount of light scattered and absorbed by small suspended particulates in the air. These small particles cause decreased visibility and soiling of surfaces. The values are recorded in Cohs[a] per 1000 linear feet of air. Samples of air are drawn through filter paper, and the reduction of light transmitted through the filter paper as a result of the dirty spot is recorded. To describe smoke measurements, a subjective rating system was devised by the New Jersey State Department of Health.[3]

With this rating system, the comparative data in Table 1 were compiled during the Birmingham air quality study. The seasonal variation in frequency of occurrence of the various smoke levels is shown in Figure 1. The curve shows that the geometric means (50% value) for the summer and fall were 0.4 and 1.1 Cohs per 1000 feet, respectively.

Table 1. Frequency of Occurrence of Smoke Shade Values

Cohs/1000 ft.	Rating[b]	Frequency of occurrence, %	
		Summer	Fall
0-0.9	Light	83	40
1.0-1.9	Moderate	13	38
2.0-2.9	Heavy	2.6	13
3.0-3.9	Very heavy	0.8	5
4.0-plus	Extremely heavy	0.6	4

[b]Based on State of New Jersey rating system.

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[a]One Coh unit is that quantity of particulate matter that produces an optical density of 0.01 on filter paper.

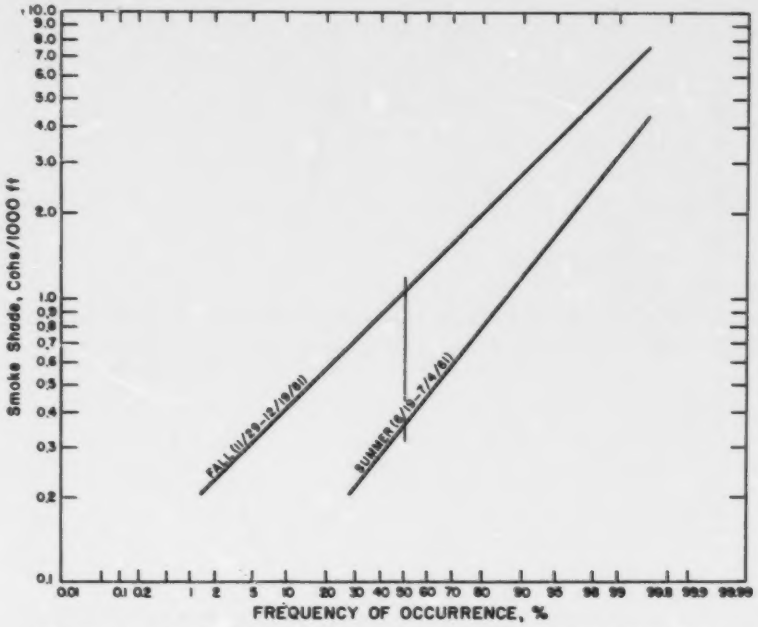

Figure 1. Seasonal variation of smoke shade in Birmingham, Alabama

Smoke shade was determined continuously throughout the study. Heavy smoke levels, greater than 1.9 Cohs per 1000 linear feet, occurred 4 percent of the time during the summer season and 22 percent of the time during the fall. In the absence of any unusual decline in industrial activity during the summer, the results would indicate that the use of space heating equipment in Birmingham greatly influences atmospheric smoke content.

In Figure 2, variations of wind speed, degree-days, and Coh values during the fall study are presented. An inverse relationship between wind speed and atmospheric smoke content is shown. Under similar atmospheric dispersion conditions, as determined by wind speed and precipitation, a positive relationship between smoke concentration and degree-days is indicated.

The diurnal variation in atmospheric smoke content during the fall study is shown in Figure 3. The peak concentration occurred during the 6- to 10-am period and a secondary peak during the 4- to 10-pm period. This pattern follows the trend of the net effect of pollution-producing activities, i.e., traffic density, consumption of fuel for heating purposes, industrial operations etc., and the fluctuation in the dispersion potential of the atmosphere.

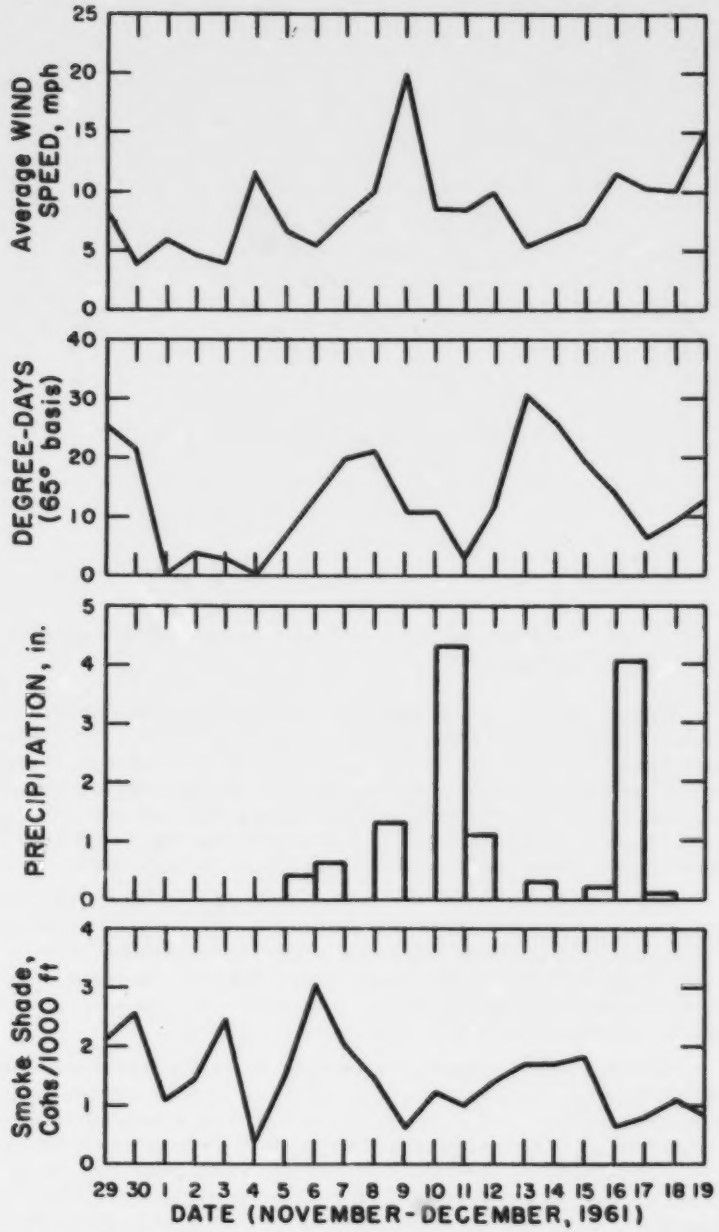

Figure 2. Variation of average daily smoke shade with selected meteorological parameters

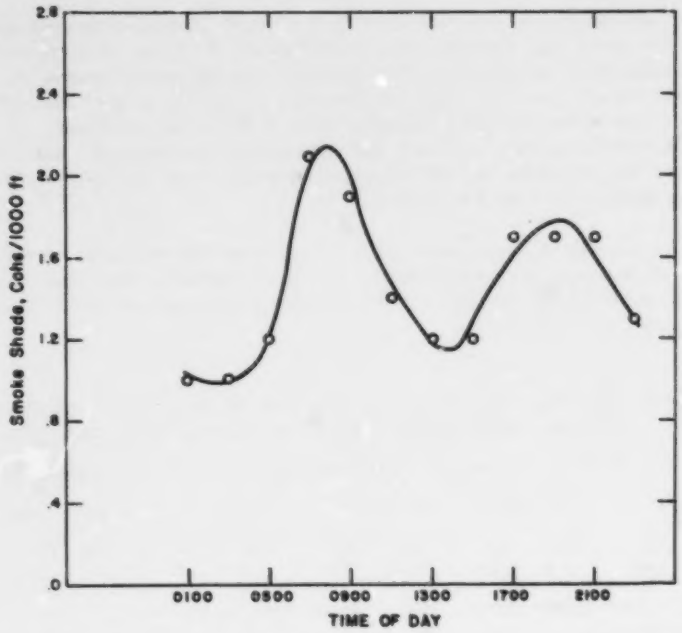

Figure 3. Diurnal variation of smoke concentration (November 29-December 19, 1961)

Total Suspended Particulates

Measurements of total suspended particulate matter give the weight of aerosols in air in micrograms per cubic meter of air. Suspended particulates arise from incomplete combustion of fuels, industrial processes, wind erosion, and other sources. Particulate concentrations during the summer phase ranged from 37 to 206 $\mu g/m^3$ of air, with an average of 106. During the winter phase, values ranged from 45 to 279 $\mu g/m^3$, of air with an average of 113.

It is interesting that in interpreting these data, the Oregon State Board of Health adopted an ambient air quality standard for suspended particulate matter of 150 $\mu g/m^3$ plus background in residential or commercial areas and 250 $\mu g/m^3$ above normal background in heavy industrial areas.[4] If the background is assumed to be 50 $\mu g/m^3$ the former level (200 $\mu g/m^3$) was exceeded once during the summer study and twice during the fall study. The data recorded for suspended particulates during the fall sampling program are not representative of levels normally expected during this season, however. Rainfall during the month of December was 13.98 inches, the wettest December in the history

of the Birmingham Weather Bureau.[5] Flash floods occurred on the 11th and 17th; rainfall was recorded on 12 of the 19 days air pollutants were measured. Undoubtedly, the pollution levels recorded would have been much higher if particulate matter had not been reduced by the good atmospheric dispersion generally associated with stormy weather and the natural "wash-out," i.e., a part of the pollutants in the atmosphere were captured by precipitation and carried to the ground.

To present a more meaningful picture of the seasonal variation of suspended particulates in Birmingham, National Air Sampling Network (NASN) data covering a 4-year period (1957-60)[6] are given in Table 2.

Table 2. National Air Sampling Network Mean Levels[a] of Suspended Particulate Matter in Micrograms per Cubic Meter[b]

Winter		Spring		Summer		Fall		1957-1961 4-year mean	
AM	GM	AM	GM	AM	GM	AM	GM	AM	GM
197	160	150	132	109	93	167	134	157	129

[a]AM - Arithmetic mean; GM - Geometric mean
[b]Reference 6.

The arithmetic mean reported by the NASN for the fall season is 167 $\mu g/m^3$ or 48 percent more than the 113 $\mu g/m^3$ mean value found in this study. This clearly demonstrates the fact that pollution levels were abnormally low during the 1961 study.

A comparison of suspended particulate levels in air over several American cities and particulate composition based on 1958 NASN data are presented in Table 3. The air over Birmingham had a suspended particulate concentration greater than that of cities of equivalent size and larger. The benzene soluble fraction, manganese, lead, tin, iron, and sulfate contents are all relatively high. The exceedingly high iron and manganese fractions in the particulates indicate that sources producing this type of emission, such as iron and steel manufacture, contribute substantially to atmospheric pollution by particulates.

Dustfall

Dustfall measurements are cumulative measurements of the large particles that settle out of the air by gravity, generally within a short distance from their source. The sample deposited is therefore an indication of the amount of large-size particulates discharged in the immediate area of exposure, i.e., generally less

Table 3. Comparison of Suspended Particulate Levels in Air over Several American Cities

City and Population[b]	Total Suspended Particulates,[c] $\mu g/m^3$	Composition,[a] $\mu g/m^3$							
		Benzene Soluble	Manganese	Lead	Tin	Iron	Titanium	Sulfate	Nitrate
Birmingham, Alabama (340,900)	157	23.0	3.3	1.1	0.1	8.8	0.12	14.6	2.9
Atlanta, Georgia (487,500)	115	17.6	0.21	0.82	0.072	2.89	0.118	9.10	2.11
Wichita, Kansas (254,700)	108	8.53	0.042	0.291	0.058	1.98	0.044	5.44	1.99
Chicago, Illinois (3,550,000)	203	17.3	0.11	0.70	0.071	3.3	0.064	16.6	2.94
Detroit, Michigan (1,670,000)	152	11.0	0.151	0.458	0.069	2.06	0.058	12.84	2.99

[a]Based on NASN data for 1958.

[b]Population figures based on 1960 census.

[c]National Air Sampling Network, (1957-1960), 4-year arithmetic mean.

than 1 mile. The weight of solids collected in the dustfall container is reported as dustfall per month in tons per square mile (tons/mi^2).

Oregon is the only state that has set standards for dustfall.[4] Levels exceeding 15 tons/mi^2 per month above background in residential or commercial land use areas and 30 tons/mi^2 above background in heavy industrial land use areas have been defined as detrimental to public welfare. Background is usually 5 to 15 tons/mi^2 per month.

Dustfall deposits ranged from 10.8 to 95.6 tons/mi^2 per month during June and 39.9 to 120.9 in December (Table 4). Dustfall at rural control site established to determine background levels measured 9.9 and 14.1 in June and December, respectively. The city-wide average, 11 sites, for June was 49.3 and for December 76.0. Highest dustfall measurements during both months were recorded at Station 8 in North Birmingham. This area can be described as residential, commercial, and industrial.

The high results indicate that an active control program directed at reducing emissions of settleable particulates is

Table 4. Dustfall Measurements in Tons per Square Mile per Month

Station number, Location and Description	December 1961			June 1961		
	Insoluble	Soluble	Total	Insoluble	Soluble	Total
1. Patton Chapel Sewage Treatment Plant, rural (background)	1.1	13.0	14.1	4.1	5.8	9.9
2. Homewood City Hall, residential, commercial	9.5	31.4	40.9	25.7	7.1	32.8
3. Mountain Brooks City Hall, residential, commercial	4.3	90.3	94.6	4.5	6.3	10.8
4. Irondale City Hall, residential, commercial	10.1	60.1	70.2	6.6	6.4	13.0
5. East Birmingham Fire Department, residential, commercial, industrial	27.2	31.4	58.6	41.2	17.7	58.9
6. Inglenook Fire Department, residential	11.8	81.1	92.9	22.4	27.3	49.7
7. Tarrant City Hall, residential, commercial, industrial	19.1	70.6	89.7	69.4	16.3	85.7
8. Acipco Baptist Church (North Birmingham), residential, commercial, industrial	26.7	94.2	120.9	47.0	48.6	95.6
9. Easley Health Center, residential, commercial, industrial	44.9	39.2	84.1	62.4	23.2	85.6
10. Brighton Fire Department, residential, commercial, industrial	24.2	15.7	39.9	22.4	32.3	54.7
11. West Eng. High School, residential, commercial, industrial	13.6	73.3	86.9	17.6	11.7	29.3
12. Alabama Medical Center, residential, commercial	17.0	39.7	56.7	15.0	10.6	25.6
City-wide average[a]	76.0			49.3		

[a]Not including Station

needed. The general fluctuation in dustfall rates with seasons indicates that emissions resulting from the combustion of fuels for space heating contribute substantially to this problem. At stations 5, 7, 8, and 9, however, only a small seasonal variation in dustfall was registered, indicating that industrial emissions may be largely responsible.

Another significant observation is the high ratio of soluble to insoluble solids in December. A possible explanation for this is that the large amounts of rainfall captured by the dustfall collectors tended to increase the proportion of soluble solids. To avoid overflow, which would have resulted in loss of sample, it was necessary to drain and recover the liquid from the collectors three times during the period of exposure.

Visibility

When an air mass has low wind speed and a stable lapse rate near the ground, poor visibility can be expected in a large city because of the presence of suspended particulate matter. Visibility

Figure 4. Effects of air pollution and fog on visibility in Birmingham at the same time (8:30 am) on different days - December 6, 1961 (upper), December 8, 1961 (lower)

is also affected by an increase in size of hygroscopic particulates under high relative humidity conditions (Figure 4). The particle size range most conducive to visibility reduction is 0.2 to 1.0 microns, mainly depending upon wavelength of light and refractive index of the particles.[7] The response of particulate pollutants to relative humidity was considered by the California State Department of Public Health when ambient air quality standards were established in 1959.[8] An adverse level is considered to have been reached when the particulate concentration is sufficient to reduce visibility to less than 3 miles at a relative humidity less than 70 percent. In this manner, an attempt is made to discriminate between natural and man-made factors in visibility reduction. The influence of particulate matter and relative humidity on visibility during this study is shown in Table 5.

The results show that smoke contributes to visibility reduction during both conditions of relative humidity (greater than or less than 70 percent) but contributes to a greater extent when relative humidity is less than 70 percent.

Table 5. Relationship of Relative Humidity, Smoke Shade, and Visibility

Period (1961)	Mean Smoke Shade Cohs/1000 ft	Visibility < 3 miles Rel. Hum. > 70%		Visibility < 3 miles Rel. Hum. < 70%	
		No. of Days	Mean Smoke Shade Cohs/1000 ft	No. of Days	Mean Smoke Shade Cohs/1000 ft
6/15-7/3 (21 days)	0.6	7	1.5	4	2.0
11/29-12/19 (21 days)	1.5	12	2.3	1	5.9

GASEOUS POLLUTANTS

Analyses were performed to determine the concentration of five gaseous pollutants in air: sulfur dioxide, nitric oxide, nitrogen dioxide, oxidants, and carbon monoxide. Concentrations are expressed as parts per million (ppm) by volume or parts per hundred million (pphm) by volume. In general, the concentration of gaseous pollutants was low, but relatively high concentrations of carbon monoxide, nitrogen oxides, and oxidants were recorded occasionally.

Sulfur Dioxide

The summer sulfur dioxide concentrations varied from less than 1.0 to 17.7 pphm, with a mean value of 1.0; the fall levels ranged from less than 1 to 12.7 pphm, with a mean value of 1.4 pphm. Sulfur dioxide levels remained consistently low throughout the fall sampling period with no sustained periods of high concentration. Atmospheric sulfur dioxide was measured for a brief period also, at a second sampling site in an industrial area in N. Birmingham; values obtained at this site were generally low and of the same order of magnitude as at the central sampling station. Highest levels during the study occurred on July 1 between 8 and 11 am when concentrations of 17.7 and 16.0 pphm were recorded. Concentrations of particulates and oxidants were al o high during this period. This accumulation of pollutants was associated with low wind speeds and a low-level atmospheric temperature inversion resulting from nighttime surface cooling by radiation. The stagnant layer of air was dissipated about noontime after the sun had warmed the earth's surface and, in turn, the lower atmospheric layer; this warming resulted in vertical air movement with good dispersion. The atmospheric sulfur dioxide dropped to 1.3 pphm at 12 noon and to less than 1 pphm at 2 pm.

The State of California selected a maximum sulfur dioxide concentration of 0.3 ppm for an 8-hour period and 1.0 ppm for 1 hour as its standard for ambient air quality.[8] Sulfur dioxide has

a taste threshold of 0.3 ppm and an odor threshold of 3.0 ppm.[9] During this study, neither the maximum permissible level selected by California nor the taste and odor threshold was recorded. It should be emphasized, however, that the limited data recorded during this short-term air-quality study should not be extrapolated to mean that adverse levels of sulfur dioxide do not occur in the Birmingham atmosphere. To determine, with any degree of certainty, the extent of sulfur dioxide as an air pollutant, measurements should be continued over a longer period and at more locations in the area than reported here. Suffice it to say that the measurements obtained did not demonstrate a serious sulfur dioxide emission problem.

Nitric Oxide - Nitrogen Dioxide

Nitrogen oxides are emitted to the atmosphere as a result of fuel combustion and industrial processes. The major sources of these pollutants are motor vehicles and larger fuel-burning installations. For this reason, higher concentrations of these gases would be expected during the heating season when emissions from space heating sources occur. The oxidizing-type smog that causes characterisitc eye irritation, respiratory tract irritation, plant damage, and visibility reduction is produced in the atmosphere in the presence of sunlight, nitrogen oxides, and unsaturated hydrocarbons. (Other organic compounds, such as oxygenates, aromatics, and paraffins, react to a lesser extent.)

During the summer study, nitrogen dioxide levels varied from less than 1.0 to 6.5 pphm, with a mean of 1.8, and during the fall phase from less than 1.0 to 4.0 pphm, with a mean value of 2.2 pphm. Nitric oxide levels during the summer period ranged from less than 1.0 to 9.0 pphm, with a mean of 1.1, and during the fall phase, from less than 1.0 to a maximum of 9.2, with a mean of 3.2. The highest levels of the combined nitrogen oxides were recorded during December 5 to 7. Variation of nitrogen oxide and other pollutant levels with wind speed and precipitation are shown in Figure 5. It should be noted that meteorological conditions during this period were unfavorable for the dispersion of pollutants, as evidenced by the simultaneous occurrence of relatively high concentrations of suspended particulates, carbon monoxide, sulfur dioxide, and low average wind speed.

No excessive nitrogen oxide was found during the study at the site of measurement. This does not preclude the possibility, however, that objectionable quantities may occur at street level or at some other time of the year. Since nitrogen oxides play a major role in photochemical smog, the measurement of these gases should be part of surveillance and control program.

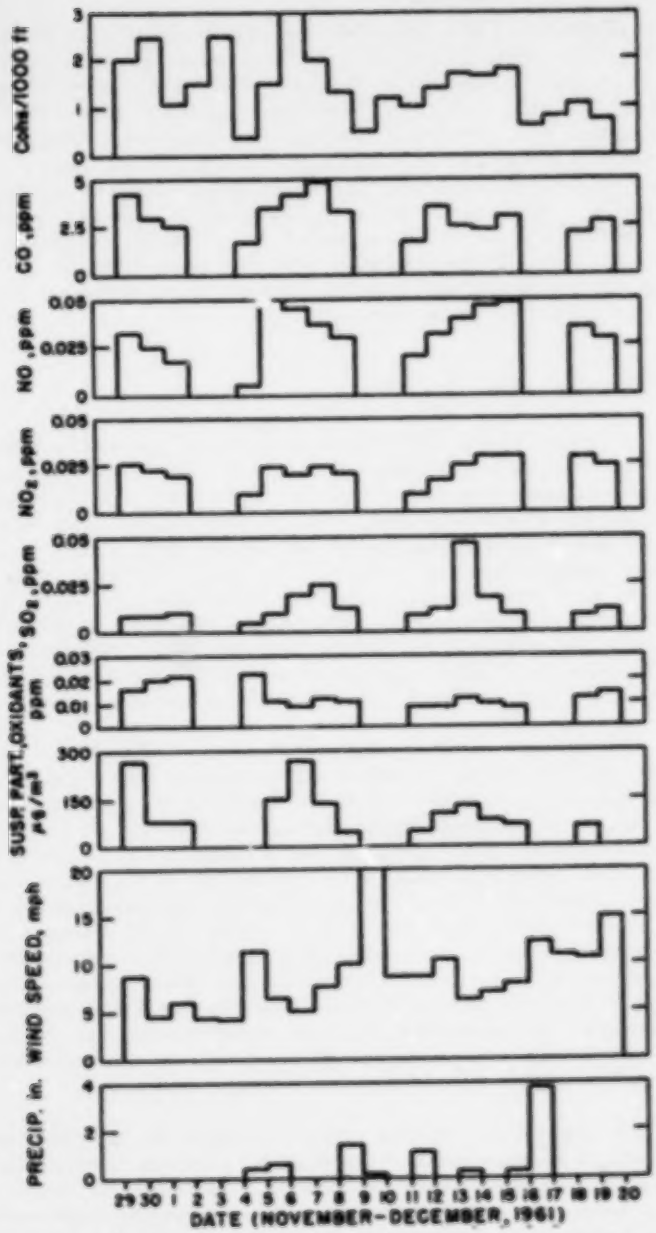
Cohs/1000 ft
CO ,ppm
NO ,ppm
NO_2 ,ppm
SO_2 ,ppm
OXIDANTS, ppm
SUSP. PART. µg/m³
WIND SPEED, mph
PRECIP. in.
29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
DATE (NOVEMBER-DECEMBER, 1961)

Figure 5. Variation of daily average levels of pollutants with daily average wind speed and precipitation.

Carbon Monoxide

The chief source of uncontrolled emission of carbon monoxide is gasoline-powered vehicles. Carbon monoxide is emitted in auto exhaust at a concentration of about 3.8 percent, or 38,000 ppm. Exposure to 30 ppm for 8 hours or 120 ppm for 1 hour is likely to impair the oxygen transport of the blood.[8]

Carbon monoxide levels ranged from less than 1.0 to 2.7 ppm during the summer study. The maximum daily average, 1.5 ppm, was recorded on July 1. The fall levels of carbon monoxide varied from a minimum of 1.0 to a maximum of 12.5 ppm, with a mean value of 3.0 ppm. Still higher concentrations undoubtedly would have been recorded at a street level sampling site in the downtown area, where traffic is dense and air movement is reduced by high buildings. The large yearly increase in motor vehicle registration in Birmingham, from 131,692 in 1950 to 249,411 in 1960, or an 83 percent increase for the 10-year period,[10] indicates atmospheric carbon monoxide will continue to increase in future years, if nothing is done to curtail exhaust emissions. For this reason, an air pollution control agency should measure the carbon monoxide in the atmosphere from time to time, particularly in the downtown area.

Oxidants

Elevated oxidant concentrations indicate the presence of photo-chemical smog in an atmosphere. This smog is a product of atmospheric reactions, principally between unsaturated hydrocarbons (e.g. butenes, pentenes) and nitrogen oxides, under the influence of strong radiation. The pollutants formed cause plant damage, rubber cracking, eye irritation, and reduced visibility. The major sources of hydrocarbons are automotive exhausts. Nitrogen oxides are emitted by automobiles and by fuel-burning units.

During the summer study, oxidant levels ranged from 1 to 20 pphm, with a mean concentration of 6 pphm. Lower concentrations, ranging from 1 to 2.7 pphm, with a mean of 1.2, were recorded in the fall. Highest hourly oxidant values were measured at the noon hour during June and at 2 pm during December. Because the reaction that causes the formation of oxidants is promoted by the energy of sunlight, one would expect a seasonal and diurnal variation in oxidant levels corresponding to the duration and intensity of sunlight.

The influence of sunlight on oxidant levels during the summer study is shown in Figure 6. A direct relationship between total hours of sunshine and oxidant level is evident.

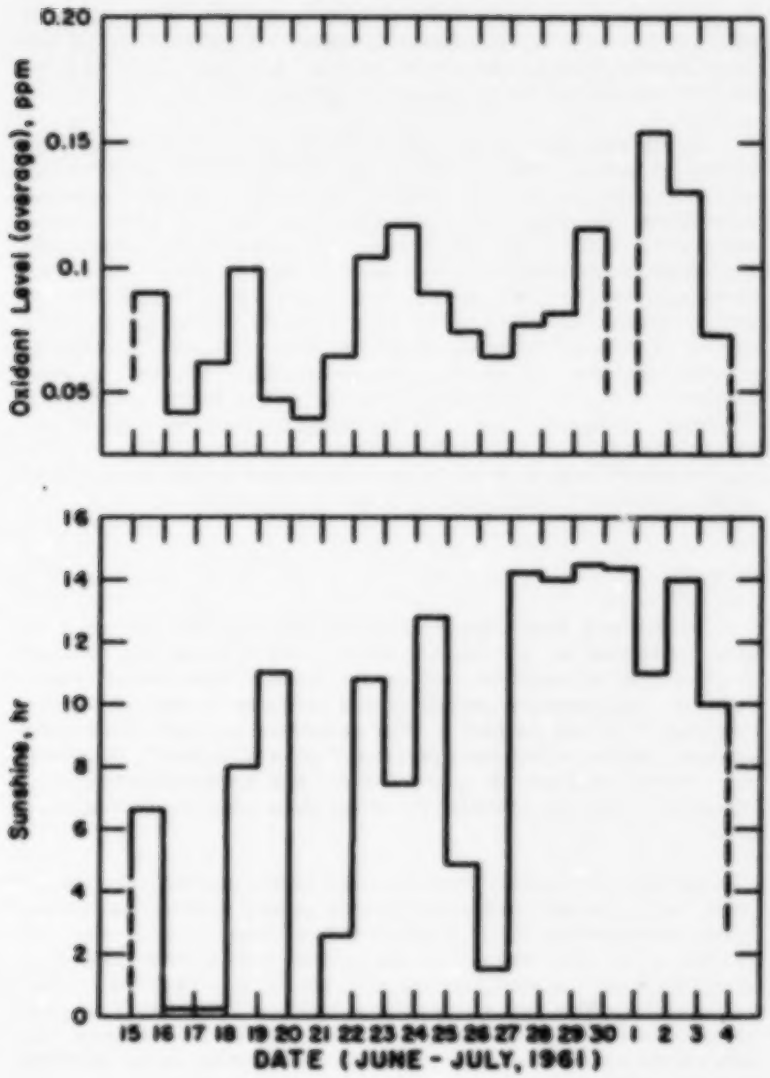

Figure 6. Variation of daily average oxidant levels with hours of sunshine

The California ambient air quality standard for oxidants is 0.15 ppm for 1 hour (as measured by the potassium iodide method), a level at which eye irritation, plant damage, and visability reduction occur.[8] The equivalent adverse level, expressed in terms of the phenolphthalin method used in this study, is assumed to be 0.30 ppm ($\frac{\text{phenolphthalin result}}{\text{potassium iodide result}} = 2$).

Highest values during these studies occurred July 1 and 2, when the values recorded were approximately one-half the adverse level. High smoke levels, low visibility, low wind speeds, and long periods of sunshine also occurred on these 2 days.

The results indicate the existence of photochemical-type pollution during the summer, but there is very little evidence of its presence during the fall. As was stated earlier, increased use of motor vehicles and greater fuel use will increase the magnitude of this type of air pollution.

Hydrogen Sulfide

About 40 houses covered with lead-base paint were affected in a paint-blackening episode that occurred February 1 and 2, 1960. The damage apparently was restricted to an area about a half mile square, south of Tarrant City. The paint damage was probably due to hydrogen sulfide in the air. Automatic hydrogen sulfide samplers were operated at four strategic sites during the summer study in an attempt to determine the possible source of the suspected causative agent. Only trace quantities of hydrogen sulfide were detected, about 0 to 2 parts per billion (ppb), and no incidents of paint blackening or odor were reported. It is possible that the source or sources responsible for the February episode were not in operation at the time of this study or that an unusual incident was responsible for the paint damage.

The odor of the hydrogen sulfide is detectable at a concentration of 25 ppb;[11] the minimum concentration of hydrogen sulfide required to produce paint damage has been estimated at 100 ppb.[12] The rate of paint blackening is increased by condensed water vapor on the painted surface.

AIR POLLUTION POTENTIAL

Atmospheric dispersion conditions affect air pollution potential. Pollutants discharged into a stable atmosphere are accumulated, resulting in higher atmospheric pollution concentrations, whereas pollutants discharged into an unstable atmosphere are diluted and dispersed more readily. The ability of the atmosphere to dilute, disperse, remove, or alter pollutants is a function of

various meteorological factors, such as wind speed, vertical temperature gradient, precipitation, and solar energy.

Based on analyses of the meteorological conditions that prevailed, air pollution conditions were near normal during the summer sampling period. Meteorological conditions during the fall sampling period were unusually favorable for the removal and dispersal of air pollutants, and therefore below-normal air pollution conditions were observed during this period.

SUMMER SAMPLING PERIOD

Degree-Days

Temperatures were below normal throughout the survey period; however, minimum temperatures were not sufficiently low to require significant use of fuel for space heating. Therefore, the number of degree-days during the summer sampling period were not important in considerations of air pollution conditions.

Wind

Generally speaking, winds from the west through the north to northeast would be expected to transport the largest amounts of air pollution to the sampling station at the Jefferson County Department of Health Building. Somewhat lesser amounts would be transported from the south to southwest, and least pollution would be transported from the northeast, east, and southeast. Wind directions were variable, with no particular pattern, during the sampling period; wind speed was much more important than direction in affecting air pollution concentrations. Nighttime wind speeds were generally conducive to the accumulation of pollutants, whereas daytime wind speeds were generally strong enough to ventilate the area. During the sampling period daytime wind speeds always reached 10.0 mph or more.

The average wind speed for the period was 7.0 mph, compared with 6.7 mph for the normal mean hourly speed for June and 6.2 for July.

Except for June 15 and 16, each day of the study had one or more hours of calm as shown below:

	June															
Date:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Hours of calm:	0	0	3	8	7	1	2	8	3	3	5	4	10	8	2	3

	July					
Date:	1	2	3	4	5	505 total hours in survey period
Hours of calm:	5	5	2	7	10	96 total hours of calm, or 19% of period

Based on consecutive hours of calm alone, the greatest accumulation of air pollution would have been expected on the night of June 18/19, with relatively large concentrations also on the nights of the 26/27 and 27/28. Least pollution would have accumulated on the nights of 15/16 and 16/17. Air pollution measurements showed that accumulations essentially followed this pattern.

Wind data for 1949 through 1954 for the Birmingham airport show that calms occurred 9 percent of the time in June and July.[2] It may be concluded from the number of hours of calm reported during this study that the potential for the accumulation of air pollution was greater than average; however, this effect was minimized by the fact that the calms generally occurred at night whereas most pollution was released by activities during the daytime. Consequently, since the average wind speed was slightly higher than normal and no outstanding meteorological events occurred, it is concluded that the air pollution concentrations measured during the survey were fairly representative for this time of the year.

Sunshine

Solar energy is necessary for the formation of photochemical-type smog. If there are no changes in the sources of air pollution, diurnal and seasonal variations in concentration would normally correspond to the solar angle and the hours of sunshine. As expected, atmospheric oxidant concentrations during the June - July survey were relatively high compared to those during the November-December survey.

The percentage of possible sunshine for the summer survey period was 61 percent compared with a normal for June of 64 percent and July of 60 percent. If all other factors are assumed to be about the same, normal amounts of oxidants would be expected during this period.

Weather Restricting Visibility

Visibility was restricted to less than a quarter mile by fog and smoke on June 22 and July 4. At these times, relative humitities of 100 percent were also reported, indicating that visibility was restricted primarily by fog.

FALL SAMPLING PERIOD

Degree-Days

Table A16 (Appendix A) shows that positive departures from normal temperatures occurred on 15 of the 21 days of the fall study. The average daily departure from normal was + 5.3°F. With regard to space heating, it is significant that December 2 to 5 was relatively warm, with no heating required on the 4th. It was also warm on the 11th and on the 17th and 18th. Only 3 days in the period had minimum temperatures below freezing and one of these, November 30, had a maximum of 61. The most space heating would have occurred on December 13, which had a minimum temperature of 26 and a maximum of 42, and on the 14th, which had a minimum of 33 and a maximum of 45. Figure 4 shows that pollution was generally high during this 2-day period, indicating that pollution levels rise with increased emissions from combustion sources.

Wind

As expected, there was less difference between day and night wind conditions during the November-December sampling period than during the June-July sampling period. There were fewer periods of calm during the nighttime hours, and, as during the summer, daytime winds were strong enough to move pollution from the area and prevent stagnation. Wind speeds of greater than 10.0 mph were recorded on 17 of the 21 days; December 9 was particularly windy, with an average speed of 19.9 mph, and December 19 was relatively windy, with an average speed of 14.9 mph.

The average wind speed for the sampling period was 8.2 mph, compared to the normal of 8.1 for November and 8.3 mph for December.

The longest consecutive calm was 8 hours on the night of November 29-30; the next longest calm occurred early on the morning of December 3, when 5 consecutive hours were reported. Figure 4 and Appendix A show high pollution levels for November 30 and December 3. (Only smoke concentration was measured on Sunday, December 3.)

A nominal number of calm hours occurred during the sampling period. During November, 9 percent of the observational hours would be expected to be calm, and in December, 10 percent; during the sampling period 9.5 percent were calm. Based only on average wind speed and percentage of hours of calm, the air pollution potential for the 3-week sampling period would be near

normal; however, the record amount of precipitation during the survey tended to lower atmospheric pollution levels. Hours of calms by dates for the fall survey are shown below:

November - December

Date:	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Hours of calm:	5	9	0	6	9	0	2	5	5	0	0	1	1	1	2	1	1	0	0	0	0

504 total hours in survey period

48 total hours of calm, or 9.5% of period

Precipitation

December 1961 was the wettest December in the history of Birmingham Weather Bureau, whose records date back to 1895, and most of the precipitation fell during the period of the survey. More than 4 inches of rain fell on the 11th and the 17th, causing flash-flooding. Some precipitation was reported on 12 of the 21 days; the first 6 days were dry. Thunderstorms occurred on December 11 and 17, and rain showers, moderate rain, or heavy rain occurred on December 6, 9, 11, 12, 14, 17, and 18. Practically the entire period from December 5 to 18 would be expected to have less air pollution because of the washout effect and the good atmospheric dissipation of pollutants associated with the stormy periods.

Atmospheric Stagnation

Highest concentrations of community-wide air pollution are likely to be associated with portions of large, slow-moving or quasi-stationary high-pressure systems, or anticyclones, that may cover an area such as Birmingham for several days. Stable conditions are produced by a combination of clear nights, which permit radiational cooling of air near the ground, and the tendency of the air from high levels to subside and be warmed aloft by compression. The stable stratum or inversion layer thus formed acts as a "lid," which effectively prevents any upward dispersion of pollution.

Korshover's study of stagnating anticyclones east of the Rocky Mountains for the period 1936-56 showed the number of

cases by months for the 21-year period in the Birmingham area.[13] The study also showed that the most likely period for the occurrence of stagnating anticyclones is in October, as shown below:

Number of Cases

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	1	0	1	3	5	3	3	6	11	4	2

There were no stagnating anticyclones during the study period. It is during this type of stable atmospheric condition, which lasts several days, that pollutants accumulate resulting in unusually high air pollution levels. Since stagnation did not occur during either of the two survey periods, it might be concluded that the accumulated pollution during these periods did not reach concentrations as high as would occur during a stagnation period with the same pollutant source conditions. In other words, the survey periods were not representative of the worst air pollution conditions that could occur.

STABILITY INDEX

Turner has presented a system for classifying atmospheric stability hourly.[14] Stability is based on surface observations available from Weather Bureau Airport Stations; the stability classes are as follows:

1. Extremely unstable
2. Unstable
3. Slightly unstable
4. Neutral
5. Slightly stable
6. Stable
7. Extremely stable

Hourly stability classifications for both periods of study are tabulated in Appendix A. A stability greater than class 4 would be conducive to the accumulation of air pollution, with the rate of accumulation proportional to the number of consecutive hours of stable conditions and to pollution emission rates.

An hourly class 7 stability occurred on 14 of the 21 days of the summer study, generally during the early morning and late evening hours between 8 pm and 6 am. Since unstable conditions prevailed during the day, this stability did not significantly affect the accumulation of daytime pollution emissions.

Class 7 conditions occurred on only 3 of the 21 days of the fall study, all between the hours of midnight and 7 am. It may be

concluded, therefore, that atmospheric conditions were generally favorable for the dispersion of pollutants and that no severe atmospheric stagnation conditions persisted.

For the two survey periods, the relationship of smoke concentration to stability class is given in Table 6 and the frequency distribution of the stability classes in Table 7.

Table 6. Relationship of Smoke Concentration to Atmospheric Stability Class

Stability Class	Smoke Concentration, Cohs/1000 ft	
	Summer	Fall
1 - 5	0.5	1.3
6 - 7	1.0	3.0

Table 7. Frequency of Occurrence of Stability Classes

	Class						
	1	2	3	4	5	6	7
	Total hours during period, %						
June 15 - July 4	2.9	10.4	16.2	39.3	8.1	8.4	14.6
Nov 29 - Dec 19	0.0	0.6	5.9	64.0	13.9	12.6	3.2

APPENDIX A
TABULATION OF AIR POLLUTION AND METEORLOGICAL MEASUREMENTS

TABLE A1. SULPHUR DIOXIDE SAMPLING RESULTS IN PARTS PER MILLION (SUMMER PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
6/15					.008	.002	.006	.003	.002				.004	.008
6/16					.052	.005	.004	.002	<.002				.013	.052
6/17					<.002	<.002	.002	<.002	<.002				<.002	.002
6/18					<.002	.002	<.002	<.002	<.002				<.002	.002
6/19					.003	.002	.005	<.002	<.002				.002	.005
6/20					<.002	<.002	.002	.002	.007				.002	.007
6/21					.002	.002	.002	.002	.002				.002	.002
6/22					.012	.014	.010	.002	---				.010	.014
6/23					.002	.003	.011	.020	---				.009	.020
6/24					.002	.002	<.002	<.002	<.002				<.002	.002
6/25					<.002	<.002	<.002	<.002	<.002	.002	<.002	.002	<.002	.002
6/26	.002	<.002	.007	.007	.002	<.002	<.002	.002	.004	<.002	<.002	.002	.002	.007
6/27	.002	.011	.028	.019	.012	.005	.004	.002	.002	.002	.003	.002	.008	.028
6/28	.003	.020	.019	.019	.012	.003	.003	.004	.003				.010	.020
6/29					---	---	<.002	<.002	<.002				<.002	<.002
7/1					.177	.160	.013	<.002	.015				.073	.177
7/2					.097	.054	.050	.026	<.002				.046	.097
7/3					.011	.008	.007	---	.003				.007	.011
7/4					.002	.003	.003	<.002	<.002				.002	.003
Hourly Average					.022	.015	.006	.004	.002					
Arithmetic Mean, all samples:					.010									

TABLE A2. SULPHUR DIOXIDE SAMPLING RESULTS IN PARTS PER MILLION (FALL PHASE)

Date (1961)	Time 0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	Daily Average	Daily Maximum
Location: Central Station														
11/29					.004	.039	.008	.008	.008				.008	.039
11/30					.010	.011	.008	.008	.004				.008	.011
12/1					.009	.017	.015	.004	.002				.009	.017
12/4					.009	.003	.002	.002	.002				.005	.009
12/5					.009	.003	.006	.012	.012				.008	.012
12/6					.027	.011	.020	.014	.023	.023	.016	.017	.019	.027
12/7	.018	.021	.056	.059	.041	.027	.022	.012	.007	.017	.014	.012	.026	.059
12/8	.038	.018	.006	.009	.025	.007	.006	.006	.008				.014	.038
12/11					.019	.008	.006	.004	---				.009	.019
12/12					.009	.005	.002	.009	.024				.012	.024
12/13					.022	---	.127	.025	.020				.049	.127
12/14					.040	.014	.015	.008	.004				.019	.040
12/15					.006	.005	.002	.009	.024				.009	.024
12/18					.018	.008	.009	.006	.005				.009	.018
12/19					.021	.014	.004	.004	.015				.012	.021
Hourly Average					.018	.010	.019	.009	.013					
Arithmetic Mean, all samples:					.016									
Location: North Birmingham[a]														
12/13					.050	.002	.002	.002	.002				.018	.050
12/14					.017	.019	.015	.015	.002				.017	.019
12/15					.002	.005	.002	.003	.006				.004	.006

[a] A second sampling station was set up at North Birmingham for a brief period, to measure sulphur dioxide.

TABLE A3. NITRIC OXIDE RESULTS IN PARTS PER MILLION (SUMMER PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
6/15					.012	.002	.003	.002	.008				.006	.012
6/16					.020	.023	.018	.017	.020				.020	.023
6/17					.015	.008	.007	.010	.008				.010	.015
6/18					.004	.002	.005	.004	.007				.004	.007
6/19					.003	.002	.005	.004	.003				.003	.005
6/20					.005	.004	.004	.004	.004				.004	.005
6/21					.004	.004	.005	.003	<.002				.003	.005
6/22					.012	.009	.002	.004	<.002				.007	.012
6/23					.010	.005	.010	<.002	<.002				.008	.010
6/24					.010	.003	.002	.002	<.002				.003	.010
6/25					.020	.003	<.002	<.002	<.002	.002	.006	.006	.005	.020
6/26	.010	.018	.004	.006	.040	.005	.007	.030	.014	<.002	.014	.080	.022	.080
6/27	.030	.070	.045	.013	.004	.004	.010	.010	.010	.010	.045	.090	.028	.090
6/28	.065	.065	.060	.030	.010	.005	.005	.005	.006				.027	.065
6/29					.004	.005	.006	<.002	.017				.008	.017
7/1					.036	.009	.005	.004	003				.011	.036
7/2					.008	.004	<.002	<.002	<.002				.005	.008
7/3					.011	.003	.002	<.002	.002				.005	.011
7/4					<.002	.002	<.002	<.002	.002				<.002	.002
Hourly Average					.012	.005	.005	.006	.006					
Arithmetic Mean, all samples:					.011									

TABLE A4. NITRIC OXIDE RESULTS IN PARTS PER MILLION (FALL PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
11/29					.050	.035	.026	.023	.033				.033	.050
11/30					.049	.025	.020	.013	.020				.025	.049
12/1					.025	.016	.019	.010	.013				.017	.025
12/4					.003	.005	.002	.002	.003				.003	.003
12/5					.052	.038	.030	.038	.043				.048	.052
12/6					.050	.042	.071	.030	.030	.042	.047	.010	.045	.071
12/7	.020	.022	.050	.071	.057	.023	.012	.025	.037	.042	.035	.0 .0	.035	.071
12/8	.023	.020	.010	.016	.042	.027	.030	.027	.040				.028	.042
12/11					.022	.017	.023	.019	.021				.020	.023
12/12					.013	.032	.030	.035	.046				.031	.046
12/13					.049	.032	.039	.031	.049				.040	.049
12/14					.050	.045	.030	.035	.045				.047	.045
12/15					.056	.051	.052	.044	.028				.050	.044
12/18					.036	.049	.030	.033	.030				.036	.049
12/19					.036	.027	.016	.021	.042				.028	.042
Hourly Average					.047	.033	.031	.029	.033					
Arithmetic Mean, all samples:					.032									

TABLE A5. NITROGEN DIOXIDE RESULTS IN PARTS PER MILLION (SUMMER PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
6/15					.024	.009	.012	.013	.020				.016	.024
6/16					.027	.020	.020	.020	.022				.022	.027
6/17					.020	.015	.017	.020	.020				.018	.020
6/18					.005	.005	.013	.010	.013				.009	.013
6/19					.013	.010	.008	.008	.006				.009	.013
6/20					.015	.014	.012	.017	.018				.015	.018
6/21					.023	.025	.025	.020	.018				.022	.025
6/22					.050	.013	.013	.009	<.002				.021	.050
6/23					.010	.007	.010	.010	<.002				.009	.010
6/24					.014	.070	.050	.005	.005				.029	.070
6/25					.020	.003	.002	.010	.014	.025	.023	.036	.016	.036
6/26	.020	.013	.013	.018	.017	.020	.023	.009	.030	<.002	.030	.037	.029	.037
6/27	.030	.030	.030	.030	.027	.017	.019	.017	.027	.040	.050	.050	.030	.050
6/28	.050	.045	.040	.045	.020	.018	.020	.010	.020				.029	.050
6/29					.013	.012	.014	<.002	.045				.026	.045
7/1					.023	.013	.009	.010	.017				.014	.023
7/2					.018	.010	.004	.006	.005				.009	.018
7/3					.026	.015	.011	<.002	.011				.016	.026
7/4					.004	.005	.010	.006	.003				.005	.010
Hourly Average					.021	.016	.015	.012	.019					
Arithmetic Mean, all samples:					.017									

TABLE A4. NITROGEN DIOXIDE RESULTS IN PARTS PER MILLION (FALL PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
11/29					.025	.020	.021	.025	.037				.026	.037
11/30					.033	.020	.016	.010	.025				.021	.033
12/1					.028	.020	.015	.016	.017				.020	.028
12/4					.013	.008	.005	.005	.008				.009	.013
12/5					.033	.021	.018	.020	.023				.023	.033
12/6					.015	.020	.017	.020	.015	.027	.022	.023	.020	.027
12/7	.017	.018	.023	.027	.025	.015	.018	.012	.043	.027	.030	.025	.024	.033
12/8	.023	.015	.013	.020	.023	.015	.023	.025	.037				.022	.037
12/11					.012	.005	.012	.007	.011				.009	.012
12/12					.008	.020	.017	.018	.021				.017	.021
12/13					.023	.026	.022	.025	.029				.025	.029
12/14					.030	.027	.029	.030	.035				.030	.035
12/15					.036	.027	.030	.040	.018				.030	.040
12/18					.024	.030	.032	.027	.020				.028	.032
12/19					.037	.024	.011	.018	.033				.025	.037
Hourly Average					.024	.020	.019	.021	.025					
Arithmetic Mean, all samples:					.022									

TABLE A7. TOTAL OXIDANT RESULTS IN PARTS PER MILLION (SUMMER PHASE)

Time	Date (1961) 6/15	6/16	6/17	6/18	6/19	6/20	6/21	6/22	6/23	6/24	6/25	6/26	6/27	6/28	6/29	7/1	7/2	7/3	Hourly Average
0000												.047	.032	.024					
0100																			
0200												.032	.017	.022					
0300																			
0400												.032	.012	.027					
0500																			
0600												.042	.017	.012					
0700													.032	.027					
0800	.024	.032	.030	.058	.055	.022	.023	.068	.092	.070	.032	.022	.070	.063	---	.200	.110	---	.065
0900	.048	.022	.034	.082	.020	.015	.027	.090	.092	.082	.073	.048	.063	.080	.054	.110	.120	.048	.069
1000	.035	.016	.034	.062	.022	.016	.041	.080	.147	.103	.063	.058	.063	.091	.088	.110	.120	.027	.070
1100	.042	.016	.036	.079	.022	.019	.068	.110	---	.082	.093	.058	.097	.070	.070	---	---	---	.062
1200	.073	.008	.036	.079	.018	.019	.068	.080	.109	.068	.073	.042	.070	.063	.137	.160	.110	.070	.072
1300	.080	.020	.036	.079	.018	.011	.068	.100	---	.053	.05.	.047	.082	.063	.080	---	---	--	.058
1400	.088	.016	.034	.079	.022	.006	.032	.060	.080	.058	.047	.027	.073	.110	.103	.110	.095	---	.061
1500	.095	.016	.045	.076	.020	.016	.053	---	.038	.032	.060	.032	.027	.073	.095	---	---	---	.049
1600	.080	.012	.045	.076	.014	.016	.027	---	---	.027	.058	.053	.103	.077	.105	.120	.080	.048	.059
1700											---	.058	.091						
1800											.027	.047	.058						
1900											---		.042						
2000											.047	.022	.027						
2100											---	---	---						
2200											.027	.027	.042						
2300																			
Daily Average	.065	.017	.038	.076	.023	.016	.040	.081	.093	.065	.052	.041	.054	.058	.091	.132	.107	.048	
Daily Maximum	.095	.032	.050	.082	.055	.022	.053	.110	.147	.103	.073	.058	.103	.110	.137	.200	.120	.070	
Arithmetic Mean, all samples:					.060														

TABLE A8. TOTAL OXIDANT RESULTS IN PARTS PER MILLION (FALL PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
11/29					.010	.018	.018	.016	.018				.016	.018
11/30					.015	.018	.018	.026	.022				.020	.026
12/1					.016	.025	.025	.027	.025				.021	.027
12/6					.018	.020	.023	.027	.024				.022	.027
12/5					.013	.013	.009	.008	.005				.010	.013
12/6					.005	.007	.009	.016	.012	.006	.007	.005	.008	.016
12/7	.007	.006	.009	.007	.016	.016	.016	.011	.016	.018	.009	.002	.011	.018
12/8	.010	.013	.010	.012	.006	.012	.012	.010	.007				.010	.013
12/11					.008	.007	.005	.008	.005				.007	.008
12/12					.005	.010	.005	.007	.007				.007	.010
12/13					.012	.011	.010	.009	.009				.010	.012
12/14					.008	.008	.010	.010	.007				.009	.010
12/15					.010	.010	.009	.005	.002				.007	.010
12/18					.008	.012	.010	.009	.010				.010	.012
12/19					.012	.010	.012	.016	.015				.013	.016
Hourly Average					.011	.013	.013	.014	.012					
Arithmetic Mean, all samples:					.012									

TABLE A9. CARBON MONOXIDE RESULTS IN PARTS PER MILLION (SUMMER PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
6/15	.8				.8	<.5	.5	<.5	.5				.5	.8
6/16					.6	.6	.7	.5	1.0				.7	1.0
6/17					<.5	<.5	<.5	<.5	<.5				<.5	<.5
6/18					<.5	<.5	<.5	<.5	<.5				<.5	<.5
6/19					<.5	<.5	<.5	<.5	<.5				<.5	<.5
6/20					<.5	<.5	<.5	<.5	.8				<.5	.8
6/21					1.0	1.5	1.5	<.5	<.5				.9	1.5
6/22					2.5	<.5	<.5	<.5	--				.9	2.5
6/23					<.5	.7	<.5	<.5	--				<.5	.7
6/24					<.5	<.5	<.5	--	<.5				<.5	<.5
6/25					<.5	<.5	<.5	.5	<.5	.8	<.5	.5	<.5	.8
6/26	.6	<.5	<.5	.6	1.6	1.5	<.5	.6	.6	.5	<.5	--	.7	1.6
6/27	.8	.8	<.5	.8	1.0	<.5	<.5	<.5	.5	.6	.6	2.0	.7	2.0
6/28	1.1	1.0	.5	2.0	1.0	.5	.5	--	<.5				.9	2.0
6/29					.5	--	<.5	--	<.5				<.5	.5
7/1					3.0	1.0	.5	.7	2.4				1.5	2.4
7/2					.8	.8	<.5	--	<.5				.6	.8
7/3					.7	1.0	.7	--	.9				.8	1.0
7/4					<.5	.5	<.5	<.5	<.5				<.5	.5
Hourly Average					.9	.7	.5	.5	.6					
Arithmetic Mean, all samples:					.7									

TABLE A10. CARBON MONOXIDE RESULTS IN PARTS PER MILLION (FALL PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
11/29					5.0	4.2	3.6	3.2	5.6				4.3	5.6
11/30					6.3	3.4	2.1	1.8	1.6				3.0	6.3
12/1					3.6	2.5	1.8	1.7	2.5				2.4	3.6
12/4					2.8	1.0	1.0	1.0	1.7				1.5	2.8
12/5					2.5	2.3	3.2	4.2	5.0				3..	4.2
12/6					5.0	2.5	5.0	3.2	4.2	3.6	5.0	5.0	4.2	5.0
12/7	1.9	1.0	1.3	3.2	3.6	5.0	8.4	---	8.4	12.5	6.3	5.0	5.1	12.5
12/8	1.4	1.0	2.3	2.8	8.4	3.6	3.2	3.2	4.2				3.3	8.4
12/11					1.6	1.3	1.8	1.7	1.7				1.6	1.8
12/12					3.6	3.6	3.2	3.6	3.6				3.5	3.6
12/13					3.2	1.9	2.3	2.5	2.8				2.5	3.2
12/14					2.3	1.8	3.2	2.1	2.3				2.3	3.2
12/15					3.2	3.2	2.8	2.8	3.2				3.0	3.2
12/18					2.8	1.9	1.9	1.5	2.5				2.1	2.8
12/19					3.2	1.7	3.2	2.8	2.8				2.7	3.2
Hourly Average					3.8	2.6	3.1	2.5	3.5					
Arithmetic Mean, all samples:					3.0									

TABLE A11. SMOKE SHADE RESULTS IN COHS PER 1000 LINEAR FEET (SUMMER PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
6/16	---	0.4	0.4	0.9	0.9	0.9	0.9	0.7	0.9	0.7	0.4	0.2	0.7	0.9
6/17	0.2	0.2	0.2	0.5	0.4	0.7	0.5	0.4	0.4	0.7	0.4	0.2	0.4	0.7
6/18	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.2	0.2	0.4
6/19	0.2	1.6	2.8	0.9	0.2	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.6	2.8
6/20	0.2	0.2	0.2	0.4	0.4	0.2	0.2	0.3	0.4	0.2	0.9	0.7	0.4	0.9
6/21	0.7	0.4	0.2	0.3	0.7	0.7	0.2	0.4	0.4	0.4	0.2	0.4	0.4	0.7
6/22	0.7	0.7	0.7	1.1	2.2	0.2	0.7	0.7	0.2	0.4	0.4	0.2	0.7	2.2
6/23	0.4	0.4	0.2	0.4	0.2	1.1	0.4	MF[a]	MF	MF	MF	MF	0.4	1.1
6/24	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.9	0.7	0.4	0.9
6/25	0.2	0	0.2	0.2	0.4	0.2	0.2	0.4	0.5	0.4	0.2	0.7	0.3	0.7
6/26	0.7	0.5	0.9	1.4	0.9	0.2	0.4	0.9	0.9	0.7	0.7	1.4	0.8	1.4
6/27	0.9	1.9	1.1	2.2	0.7	0.9	0.2	0.2	0.2	0.7	1.4	1.4	1.0	2.2
6/28	1.9	2.8	3.0	2.2	1.9	0.7	0.4	0.4	0.2	0.7	0.9	0.4	1.4	3.0
6/29	0.9	0.2	0.2	0.2	0.9	0.2	0.2	0.2	0.2	0.2	0.4	0.2	0.3	0.9
6/20	0.9	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.7	0.7	0.4	0.9
7/1	0 9	1.6	1.6	2.8	1.6	0.4	0.4	0.9	0.4	0.4	0.4	1.1	1.1	2.8
7/2	1.1	1.9	1.6	0.9	1.1	0.7	0.2	0.2	0.2	0.4	0.2	0.2	0.8	1.9
7/3	0.2	0.2	0.2	0.7	0.9	1.1	1.1	0.9	0.4	0.2	0.2	1.1	0.7	1.1
7/4	0.9	1.4	1.1	1.1	0.7	0.2	0.2	0.2	0.2	0.4	1.1	1.6	0.8	1.6
Hourly Average	0.6	0.8	0.7	0.9	0.8	0.5	0.4	0.4	0.4	0.4	0.6	0.6		

Arithmetic Mean, all samples: 0.6

[a] MF - Malfunction

TABLE A12. SMOKE SHADE RESULTS IN COHS PER 1000 LINEAR FEET (FALL PHASE)

Date (1961)	Time												Daily Average	Daily Maximum
	0000	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200		
11/29	1.1	0.7	1.3	1.8	2.7	2.4	1.9	1.3	1.8	2.7	3.6	3.3	2.1	3.6
11/30	3.0	3.9	3.6	5.9	2.1	2.1	0.7	1.1	2.5	2.4	2.4	1.5	2.6	5.9
12/1	1.1	0.6	1.0	1.6	1.3	1.0	0.6	1.1	1.4	1.4	1.3	0.7	1.1	1.6
12/2	0.3	0.5	1.0	1.0	0.7	0.6	0.6	0.7	1.5	3.3	3.6	4.2	1.5	4.2
12/3	4.6	4.6	4.0	6.2	6.1	0.6	0.2	0.7	0.3	0.2	0.5	0.3	2.4	6.2
12/4	0.6	0.2	0.6	0.7	0.5	0.3	0.3	0.3	0.3	0.5	0.8	---	0.4	0.8
12/5	0.6	0.6	0.5	1.5	1.3	1.4	1.9	2.2	2.5	2.1	1.9	0.9	1.5	2.5
12/6	0.7	1.4	1.7	3.6	4.0	4.2	4.7	2.1	2.5	3.6	4.5	3.8	3.1	4.7
12/7	1.7	1.4	2.5	5.7	3.1	1.4	1.2	1.0	1.5	1.8	1.6	1.3	2.0	5.7
12/8	0.7	0.4	1.1	1.5	1.5	1.1	1.6	1.1	1.7	2.2	2.2	1.5	1.4	2.2
12/9	0.5	0.3	0.4	0.7	0.9	0.2	0.5	0.2	0.7	0.6	1.1	0.3	0.5	1.1
12/10	0.3	0.6	1.0	2.4	1.8	2.1	1.3	1.1	1.4	1.1	1.2	0.4	1.2	2.4
12/11	0.9	0.2	0.5	1.0	1.0	0.7	1.1	0.8	3.2	1.2	1.2	0.4	1.0	3.2
12/12	0.4	1.0	0.4	1.1	2.3	2.3	1.6	2.2	2.2	1.6	0.9	0.7	1.4	2.3
12/13	0.7	0.2	1.0	1.5	1.7	1.6	1.4	1.5	2.8	2.6	2.8	2.1	1.7	2.8
12/14	1.1	1.2	1.7	2.5	1.4	1.7	1.0	1.3	3.0	2.1	1.6	1.3	1.7	3.0
12/15	1.4	1.2	1.1	2.5	1.4	2.2	1.9	2.5	1.8	2.7	2.1	1.3	1.8	2.7
12/16	0.3	0.4	0.7	0.2	1.0	0.4	0.9	1.2	0.6	0.7	0.4	0.2	0.6	1.2
12/17	0.4	0.1	0.3	0.5	2.3	0.6	0.8	1.5	0.6	1.2	1.2	0.6	0.8	2.3
12/18	0.3	0.2	0.2	1.8	2.1	1.3	1.3	1.9	1.5	1.2	0.6	0.4	1.1	2.1
12/19	0.7	0.6	0.4	1.4	1.6	1.0	1.0	0.3	1.1	0.4	0.4	0.6	0.8	1.6
Hourly Average	1.0	1.0	1.2	2.1	1.9	1.4	1.2	1.2	1.7	1.7	1.7	1.3		
Arithmetic Mean, all samples:					1.5									

TABLE A13. SUSPENDED PARTICULATE MATTER IN MICROGRAMS PER CUBIC METER

Date (1961)	Sampling Points	
	Central Station	North Birmingham Station
Summer Phase		
6/14	92	
6/15	58	
6/16	75	
6/17	60	
6/18	51	
6/19	112	
6/20	37	
6/21	93	
6/22	155	
6/23	112	
6/24	164	
6/25	67	
6/26	57	
6/27	136	
6/28	206	
6/29	107	
6/30	73	
7/1	172	
7/2	155	
7/3	128	
7/4	111	
Arithmetic Mean	106	
Fall Phase		
11/30	270	
12/1	78	
12/2	75	
12/5	63	
12/6	146	
12/7	279	
12/8	133	
12/9	48	
12/12	45	
12/13	104	
12/14	129	112
12/15	89	65
12/16	72	104
12/19	63	76
Arithmetic Mean	113	

TABLE A14. LOCAL CLIMATOLOGICAL DATA (SUMMER PHASE)

	Date, 1961																				
	6/15	6/16	6/17	6/18	6/19	6/20	6/21	6/22	6/23	6/24	6/25	6/26	6/27	6/28	6/29	6/30	7/1	7/2	7/3	7/4	7/5
Temperature, °F																					
Maximum	91	66	68	81	80	71	77	85	84	86	80	72	84	87	89	91	92	92	89	88	91
Minimum	64	59	57	62	62	65	64	57	60	59	66	60	55	58	65	66	65	64	66	63	59
Average	78	63	63	72	71	68	71	71	72	73	73	66	70	73	77	79	79	78	78	76	75
Departure from Normal	0	-15	-15	-6	-7	-10	-7	-7	-7	-6	-6	-13	-9	-6	-2	0	-1	-2	-2	-4	-5
Precipitation (water equivalent), in.	.34	T	T	T	T	.72	.01	0	.43	T	.22	.94	0	0	0	0	T	0	.17	0	0
Wind																					
Prevailing direction	W	NNW	ENE	SE	SSE	ESE	NNW	WSW	SW	SSW	S	ENE	N	NE	ENE	NE	WSW	WSW	SW	NNW	SSE
Average speed, mph	12.8	9.8	6.3	4.7	7.8	11.0	10.7	4.8	8.5	7.7	4.8	7.4	5.8	7.0	7.2	4.7	4.4	6.4	7.2	5.0	3.2
Fastest mile, mph	19	13	10	13	17	24	17	16	22	27	11	17	17	17	15	11	13	14	18	10	10
Direction	NW	NE	NE	NE	SE	SE	N	SW	SW	SW	SE	NE	N	N	NE	SE	SE	SW	SE	N	NE
Sunshine																					
Total, hr and min	6:41	0:00	0:00	7:59	10:58	0:00	2:36	10:36	7:25	12:48	4:57	1:34	14:15	13:58	14:22	14:21	10:58	14:06	10:01	12:45	13:54
Percent of possible	46	0	0	56	76	0	18	76	52	89	34	11	99	97	100	100	76	98	70	89	97
Sky Cover																					
Sunrise to sunset, tenths	9	10	10	6	8	10	10	5	7	4	10	10	2	4	2	2	4	3	8	2	3
Midnight to midnight, tenths	9	10	10	6	8	10	8	3	5	5	10	8	2	3	2	1	4	3	8	3	2

TABLE A15. LOCAL CLIMATOLOGICAL DATA (FALL PHASE)

	Date, 1961																				
	11/29	11/30	12/1	12/2	12/3	12/4	12/5	12/6	12/7	12/8	12/9	12/10	12/11	12/12	12/13	12/14	12/15	12/16	12/17	12/18	12/19
Temperature, °F																					
Maximum	52	61	67	71	75	75	67	57	56	48	63	62	69	69	42	45	51	55	62	63	61
Minimum	27	27	39	51	49	61	48	46	34	39	44	45	56	35	26	33	43	49	55	49	42
Average	40	44	53	61	62	68	58	52	45	44	54	54	63	52	34	39	47	52	59	56	52
Departure from Normal	-8	-4	+6	+14	+15	+21	+11	+5	-2	-3	+8	+8	+17	+6	-12	-7	+1	+6	+13	+10	+6
Degree-days (base 65°)	25	21	12-	4	3	0	7	13	20	21	11	11	2	13	31	26	18	13	6	9	13
Precipitation, inches (water equivalent)	0	0	0	0	0	0	.42	.65	0	.02	1.39	.11	4.35	1.15	0	.33	.01	.15	4.06	.03	0
Wind																					
Prevailing direction	N	E	SSE	SSW	SSE	S	NW	W	NNW	ENE	SE	ENE	SSE	WNW	NNW	ENE	NE	SE	SE	WSW	SSW
Average speed (mph)	8.7	4.0	6.0	4.4	4.1	11.5	6.3	5.4	7.8	10.1	19.9	8.2	8.2	10.3	5.6	6.3	7.5	11.8	10.2	10.1	14.9
Fastest mile (mph)	13	11	12	11	13	22	17	12	14	19	30	14	21	38	15	14	14	17	17	23	22
Direction	N	E	SE	SW	SW	S	SW	N	N	N	S	N	NW	SW	N	E	NE	SE	NW	SW	W
Sunshine,																					
Total, hours and minutes	10:08	9:16	6:33	1:48	9:23	5:09	0:00	0:00	10.10	0:00	0:00	0:00	0:00	0:00	9:58	0:00	0:00	0:00	0:00	0:00	7:17
Percent of possible	100	92	65	18	93	51	0	0	100	0	0	0	0	0	100	0	0	0	0	0	73
Sky Cover																					
Sunrise to sunset (tenths)	1	7	5	9	3	9	10	10	0	10	10	10	10	10	0	10	10	10	10	10	2
Midnight to midnight (tenths)	2	6	5	9	4	9	10	7	1	10	10	10	10	10	3	10	10	10	10	9	4

PRESS CO

TABLE A16. HOURLY PRECIPITATION IN INCHES (FALL PHASE)

Date (1961)	Time																							
	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
11/29																								
11/30																								
12/1																								
12/2																								
12/3																								
12/4																								
12/5	T	.10	.02	.02	.01	T	T	.07	T	.01	.01		T	T	.01	.02	.03	.03	.03	.03	.02	T	T	.01
12/6	T	.01	.11	.19	.09	.06	.07	.03	.04	.01	T	T	T	T										
12/7																								
12/8																								
12/9	.05	.01	.02	.01	.01												T	T	T	T	T	T	T	.02
12/10	.05	.02	.01	.02	.01	T	T	T	T	T									.04	.70	.35	.18	.01	.01
12/11					T	T	T	T	T	.06	T	.07	.03	T	.63	.92	.12	.47	1.47	.38	.15	.03	.02	T
12/12	.09	.01	.03	.28	.03	.06	.16	.02	.03	.13	.02	.04	.08	.02	.06	.07	.01	.01	T					
12/13																								
12/14			T	T	T	T	T	T	.09	.03	.03	.04	T	T	.01	T	.06	.03	.01	.02	.01	T		
12/15			T	T	T	T						T	T			T	T	.01			T	T	T	T
12/16	.06	T		.01	T	.02	.03	T	.01		.01	T						T	T			T	T	.01
12/17	.02	T	T	T	.05	.03	.06	.27	.60	.21	.01	.03	.01	.10	.12	.05	.17	.20	.24	.20	.84	.42	.19	.24
12/18	T	T	.01	.02					T	T														
12/19																								

TABLE A17. STABILITY INDEX (SUMMER PHASE) [a]

Date (1961)	Time																							
	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
6/15	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	4
6/16	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6/17	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6
6/18	6	5	5	5	4	4	4	3	2	1	2	3	1	4	3	4	4	4	7	6	6	7	7	7
6/19	7	7	7	7	7	3	3	3	3	3	4	3	4	4	4	4	4	4	4	4	4	4	4	4
6/20	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
6/21	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6
6/22	6	6	7	7	7	4	4	4	?	3	3	3	3	3	3	3	3	4	5	7	7	7	7	7
6/23	7	7	7	7	7	3	3	3	4	4	4	4	4	4	4	4	4	4	5	6	4	6	7	7
6/24	7	7	7	7	6	4	2	2	2	1	2	4	3	4	4	4	4	4	4	4	4	5	7	4
6/25	4	4	4	4	4	4	4	3	2	2	4	2	3	4	2	3	4	4	6	6	4	4	4	4
6/26	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6	7	7	7	7
6/27	7	7	7	7	7	3	2	2	3	3	3	3	3	3	3	4	4	4	6	7	7	7	7	7
6/28	7	7	7	7	7	3	2	2	3	4	4	4	4	4	4	3	4	4	6	7	6	6	6	7
6/29	7	7	7	7	5	4	3	3	3	2	3	3	3	3	3	3	3	4	6	7	6	7	7	6
6/30	6	7	7	7	7	3	2	2	2	1	2	1	1	3	2	3	3	5	6	6	6	7	7	7
7/1	7	7	7	7	7	3	2	2	2	2	1	2	3	1	2	1	4	4	4	5	5	5	6	6
7/2	7	7	7	7	7	3	2	2	2	1	1	3	3	3	4	3	4	4	5	5	6	5	4	4
7/3	5	5	5	6	5	4	3	3	4	4	4	4	4	3	4	4	4	4	5	5	5	7	7	7
7/4	4	4	4	4	4	4	2	2	2	3	2	2	2	2	3	3	4	4	6	7	7	7	7	7

[a] Reference 14.

TABLE A18. STABILITY INDEX (FALL PHASE) [a]

Date (1961)	Time																							
	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
11/29	4	6	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	5	6	6	6	6	6	4
11/30	7	7	6	7	7	6	4	4	3	3	2	3	3	3	3	4	6	6	6	6	6	5	6	7
12/1	5	5	5	5	5	4	4	5	3	3	2	3	3	3	3	4	6	6	6	5	5	6	5	5
12/2	5	4	4	6	4	5	3	4	4	3	4	4	4	4	4	4	4	4	6	6	5	5	6	6
12/3	6	7	6	7	7	7	7	3	3	3	3	3	4	3	4	4	6	6	5	6	6	5	4	5
12/4	5	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4
12/5	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	3	4	4	4	4	4	6	4	4
12/6	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6	5	6	6	5	4
12/7	5	7	7	6	7	7	7	3	3	4	4	4	4	4	4	4	6	6	6	6	6	5	4	6
12/8	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12/9	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12/10	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12/11	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4	4
12/12	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12/13	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	4	5	5	6	6	6	6	7	4
12/14	6	6	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	5
12/15	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12/16	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12/17	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
12/18	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	4
12/19	5	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6

[a] Reference 14.

APPENDIX B
ANALYTICAL PROCEDURES

Smoke Shade

Suspended Particulates

Dustfall

Sulfur Dioxide

Oxidants

Oxides of Nitrogen

Carbon Monoxide

Hydrogen Sulfide

ANALYTICAL PROCEDURES

Smoke Shade

Smoke shade was determined continuously throughout the study with an AISI automatic strip filter paper sampler. In this sampler air is drawn through a 1-inch-diameter circular area of a strip of Whatman #4 filter paper at a rate of approximately 0.25 cubic feet per minute; after 2 hours the filter strip is moved to a new position and the cycle repeated. At intervals of 2 or 3 days the used filter paper is removed. The percent light transmission through dirty spots compared with that through the clean paper, is determined with a spot evaluator. Cohs per 1000 linear feet of air are determined directly from a calibration curve.

Suspended Particulates

Suspended particulate loading was determined with the high-volume filter paper sampler. This sampler aspirates air through a tared glass fiber filter web for 24 hours at approximately 50 cfm. Initial and final flow rates for each sampling period are determined, along with actual sampling time. The filter webs are dried at 60°C overnight and reweighed. Suspended particulate concentrations are calculated in micrograms per cubic meter (ug/m^3).

Dustfall

Dustfall was collected in a wide-mouthed plastic container 10.5 inches high, 8 inches in diameter at the top, and 6.5 inches in diameter at the bottom (Figure B1). For these surveys 500

Figure B1. Dust collector located on the roof of the Irondale City Hall

milliliters of distilled water was added to prevent dispersion losses of settled particles by wind currents, and 2 milligrams of quaternary ammonium chloride as a fungicide. During the winter phase, 50 milliliters of 95 percent isopropyl alcohol was added to prevent freezing.

The sample collected in the dustfall sampler is filtered through a tared filter paper; the paper is dried at 110°C and reweighed. The weight gain represents water insoluble dustfall. The filtrate is evaporated to 100 milliliters on a hot plate, transferred to a tared breaker, and evaporated to dryness over low heat. The beaker is dried at 110°C and reweighed; the net weight gain represents water soluble dustfall. The area of the mouth of the container is calculated, the total sampling time noted, and the dustfall determined. Dustfall rates are reported in tons per square mile per month.

Sulfur Dioxide

Sulfur dioxide in the air samples was determined by the West and Gaeke method.[15] Ambient air is metered at a rate of 4.0 liters per minute for 30 minutes through a fritted glass bubbler containing 10 milliliters of 0.1 M sodium tetrachloromercurate as a scrubbing agent. A 10-milliliter blank is prepared at the same time as the sample and allowed to stand open to the air.

At the end of the 30-minute sampling period 1 milliliter of 0.01 percent bleached p-rosaniline hydrochloride and 1 milliliter of 0.2 percent formaldehyde solution are added; the solution is mixed and allowed to stand for 20 minutes for full color development. Optical density is read on a Spectronic "20" spectrophotometer at 560 millimicrons.

Sulfur dioxide concentrations are determined from a standard reference curve and reported in parts per million by volume.

Oxidants

Total oxidants were determined by the method of Haagen-Smit.[16] Air is drawn through a midget impinger at a rate of 1.0 liter per minute for all oxidant samples. Phenolphthalin is used as the absorbing solution. A reagent blank is prepared at the same time as the sample and allowed to stand open to the atmosphere. The optical density of the colored solution formed is determined on a Spectronic "20" spectrophotometer at 550 millimicrons immediately after collection and oxidant concentrations in parts per million by volume are taken from a standard curve.

During the summer phase of sampling, a 15-minute sampling period produced sufficient color in the 0.35 percent phenolphthalin absorbing solution. Because of the lower oxidant levels in the fall, however, a 30-minute sampling period was used in November. Also, the phenolphthalin solution was buffered at pH 11.5 to eliminate color fading during the longer sampling period.[17]

In the preparation of the standard curve, a 30 percent hydrogen peroxide solution was diluted 1:100 and standardized with standard iodine solution. From the standardized solution a working stock containing 1.4 micrograms per milliliter was prepared so that each milliliter would represent 1.0 microliter of oxidant as hydrogen peroxide at 25°C and 1 atmosphere pressure. A calibration curve was prepared, for the range 0 to 9 microliters H_2O_2, by adding increments of the standard solution to phenophthalin and copper sulfate reagents and adjusting the volume to 10 milliliters with a buffer solution (pH 11.5).

Oxides of Nitrogen

Oxides of nitrogen were determined in a 3-unit sampling train by the Saltzman method.[18] In the first bubbler, nitrogen dioxide is absorbed in Saltzman reagent. In the next bubbler, the air is passed through a 2.5 percent solution of potassium permanganate in 2.5 percent sulfuric acid, which oxidizes the nitric oxide to nitrogen dioxide.[19] The converted nitrogen dioxide is removed in a third bubbler containing Saltzman reagent.

The air sample is drawn through fritted glass bubblers at a rate of 0.4 liters per minute for 30 minutes. The pollutants are absorbed in 10 milliliters of Saltzman reagent containing 0.02 percent N-(1-naphthyl) -ethylenediamine - dihydrochloride, 0.5 percent sulfanilic acid, and 1.4 percent glacial acetic acid. A blank is prepared simultaneously with the sample and exposed to the same environmental conditions as the sampling bubbler.

After the 30 minutes allowed for full color development, samples are read on the Spectronic "20" spectrophotometer at 550 millimicrons and the optical density recorded. The concentration of nitrogen dioxide is taken from the standard curve, and the parts per million by volume calculated. The oxidized nitric oxide is determined as nitrogen dioxide from the standard curve, since the microliters of nitrogen dioxide found in bubbler No. 3 equals the microliters of nitric oxide found in the air.

Carbon Monoxide

Carbon monoxide was determined by use of Mine Safety Appliance Company indicator tubes made in accordance with a National Bureau of Standards technique.[20] Air is sampled through

a carbon monoxide detector tube, packed with a silica gel guard that removes impurities, an indicating gel, and a second guard gel. The indicator gel is a purified silica gel impregnated with a sulfuric acid solution of ammonium molybdate and palladous sulfate, which, on adsorption of carbon monoxide, turns uniformly from yellow to blue-green by the formation of molybdenum blue on the gel.

Air at ambient temperature is drawn through the detector tube at a rate of 0.1 liter per minute until the appearance of a definite color change from yellow to blue-green. This color change is determined visually by comparison with an unused detector tube and a standard color chart. The concentration of atmospheric carbon monoxide is calculated from the amount of air sample necessary to provide a preset mass of carbon monoxide. The carbon monoxide concentration is calculated in parts per million by volume.

Hydrogen Sulfide

Hydrogen sulfide as lead sulfide was determined photometrically by use of the AISI Automatic Smoke Sampler.[12] A suction pump draws air at a rate of approximately 0.25 cubic foot per minute through a prefilter to remove particulate matter. A humidifier to moisten the air sample and through 1-inch circle filter paper tape impregnated with lead acetate. A timing mechanism shifts the paper tape into a new position after a desired time interval. The extent of blackening of the lead sulfide spot, as measured with a densitometer, is proportional to the hydrogen sulfide content of the air sample.

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